THE HEART (2)

(BLOOD SUPPLY AND INNERVATION)

Lecture (7)

Last updated: April 2013

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Objectives:

- **Basic anatomy, to identify:**
  - Coronary arteries and their branches.
  - Coronary sinus and its tributaries.
  - Parts of the conducting system of the heart.
- **Clinical anatomy, to define:**
  - Myocardial Infarction.
  - Coronary Bypass Graft.
  - Coronary Angioplasty.
  - Referred pain
- **Radiology, to define:**
  - CoronaryAngiography.

Think about this

- Mustafa is 65 years old teacher brought to the E.R complaining of severe and sharp chest pain, he told the resident doctor that the pain was initially in his shoulder, he was known diabetic, hypertensive and heavy smoker for 10 years.
- ECG showed ST segment elevation in V1, V2 and V3, after work up the doctor made the diagnosis of myocardial infarction.

By the end of this lecture, try to answer these questions about the previous story:

A. Why did the patient feel the pain in his shoulder first?
B. Describe the innervation of the heart.
C. From the mentioned leads on ECG, which artery could be affected?

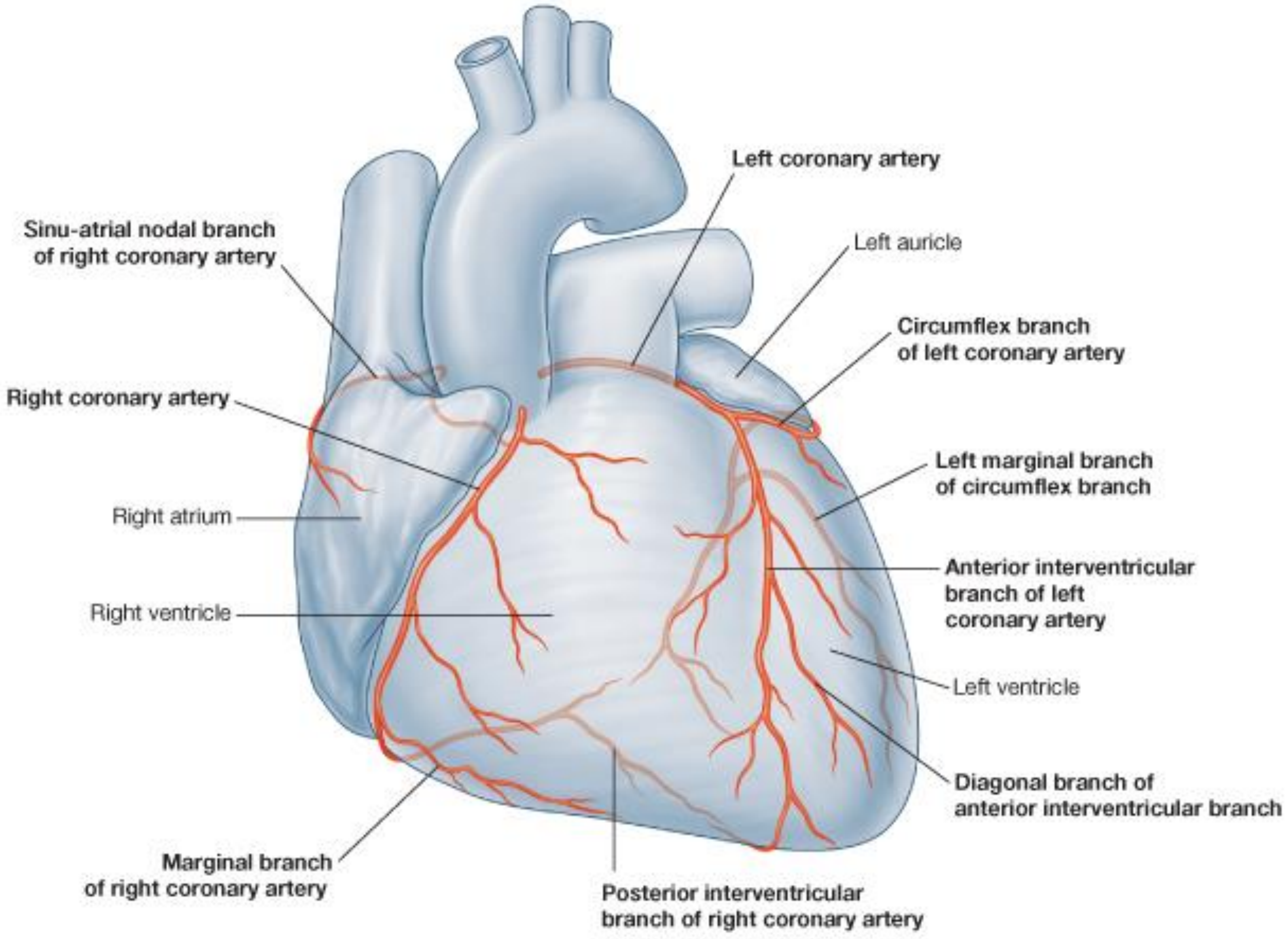
Introduction: Lecture's map

- **Blood supply:**
  - Right and left coronary arteries.
- **Venous drainage:**
  - Coronary sinus.
- Conducting system of the heart.

Blood supply of the heart

Coronary arteries:

- Right coronary artery.
- Left coronary artery.


Left coronary artery
Sinu-atrial nodal branch of right coronary artery
Left auricle
Circumflex branch of left coronary artery
Right coronary artery
Left marginal branch of circumflex branch
Right atrium
Anterior interventricular branch of left coronary artery
Right ventricle
Left ventricle
Diagonal branch of anterior interventricular branch
Marginal branch of right coronary artery
Posterior interventricular branch of right coronary artery

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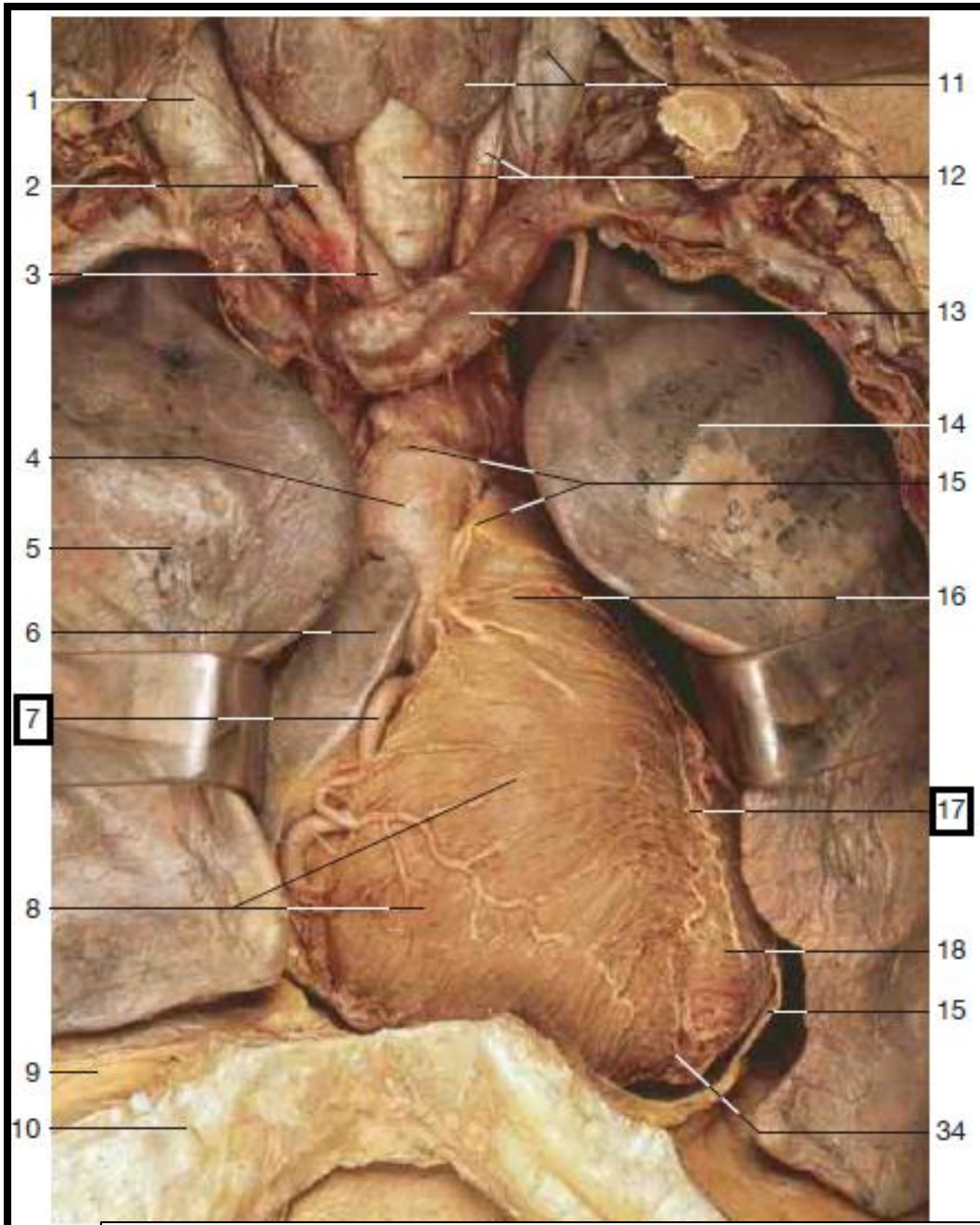
Artery	Origin	Course	Distribution	Anastomosis
Right coronary	Right aortic sinus	Follows (AV) groove between atria and ventricles	Right atrium, SA and AV nodes, and posterior part of IVS	Circumflex and anterior IV branches of left coronary artery
Left coronary	Left aortic sinus		Most of left atrium and ventricle, IVS, and AV bundles; may supply AV node	Right coronary artery



Heart in situ. Myocardium and coronary arteries (anterior aspect).

1	Internal jugular vein
2	Common carotid artery
3	Brachiocephalic trunk
4	Ascending aorta
5	Right lung
6	Right auricle
7	Right coronary artery
8	Myocardium of right ventricle
9	Diaphragm
10	Costal margin
11	Thyroid gland and internal jugular vein
12	Trachea and left common carotid artery
13	Left brachiocephalic vein
14	Left lung
15	Pericardium (cut edge)
16	Pulmonary trunk
17	Anterior interventricular artery
18	Myocardium of left ventricle
34	Apex of heart

Image from: Johannes W.Rohen; Chihiro Yokochi; Elke Lütjen-Drecoll. Color atlas of anatomy. 7th edition. Lippincott Williams & Wilkins 2011

Right coronary artery

Branch	Origin	Course	Distribution	Anastomoses
SA nodal	Right coronary artery near its origin	Ascends to SA node	Pulmonary trunk and SA node	
Right marginal	Right coronary artery	Passes to inferior margin of heart and apex	Right ventricle and apex of heart	IV branches
Posterior interventricular	Right coronary artery (in 67%)	Runs in posterior IV groove to apex of heart	Right and left ventricles and posterior third of IVS	Anterior IV branch of left coronary artery (at apex)
AV nodal	Right coronary artery near origin of posterior IV artery	Passes to AV node	AV node	

Left coronary artery

Artery/Branch	Origin	Course	Distribution	Anastomoses
SA nodal	Circumflex branch (in 40%)	Ascends on posterior surface of left atrium to SA node	Left atrium and SA node	
Anterior interventricular	Left coronary artery	Passes along anterior IV groove to apex of heart	Right and left ventricles and anterior two thirds of IVS	Posterior IV branch of right coronary artery (at apex)
Circumflex	Left coronary artery	Passes to left in AV groove and runs to posterior surface of heart	Left atrium and left ventricle	Right coronary artery
Left marginal	Circumflex branch	Follows left border of heart	Left ventricle	IV branches
Posterior interventricular	Left coronary artery (in 33%)	Runs in posterior IV groove to apex of heart	Right and left ventricles and posterior third of IVS	Anterior IV branch of left coronary artery (at apex)

Clinical note: Myocardial Infarction (1)

- With sudden occlusion of a major artery by an embolus (G. embolos, plug), the region of myocardium supplied by the occluded vessel becomes infarcted (rendered virtually bloodless) and undergoes necrosis (pathological tissue death).

Clinical note: Myocardial Infarction (2)

- The three most common sites of coronary artery occlusion and the percentage of occlusions involving each artery are:
  - Anterior IV (LAD) branch of the LCA (40 to 50%).
  - RCA (30 to 40%).
  - Circumflex branch of the LCA (15 to 20%).

Think about this

- **Angina pectoris:**

(L. angina: strangling pain + L. pectoris: of the chest).

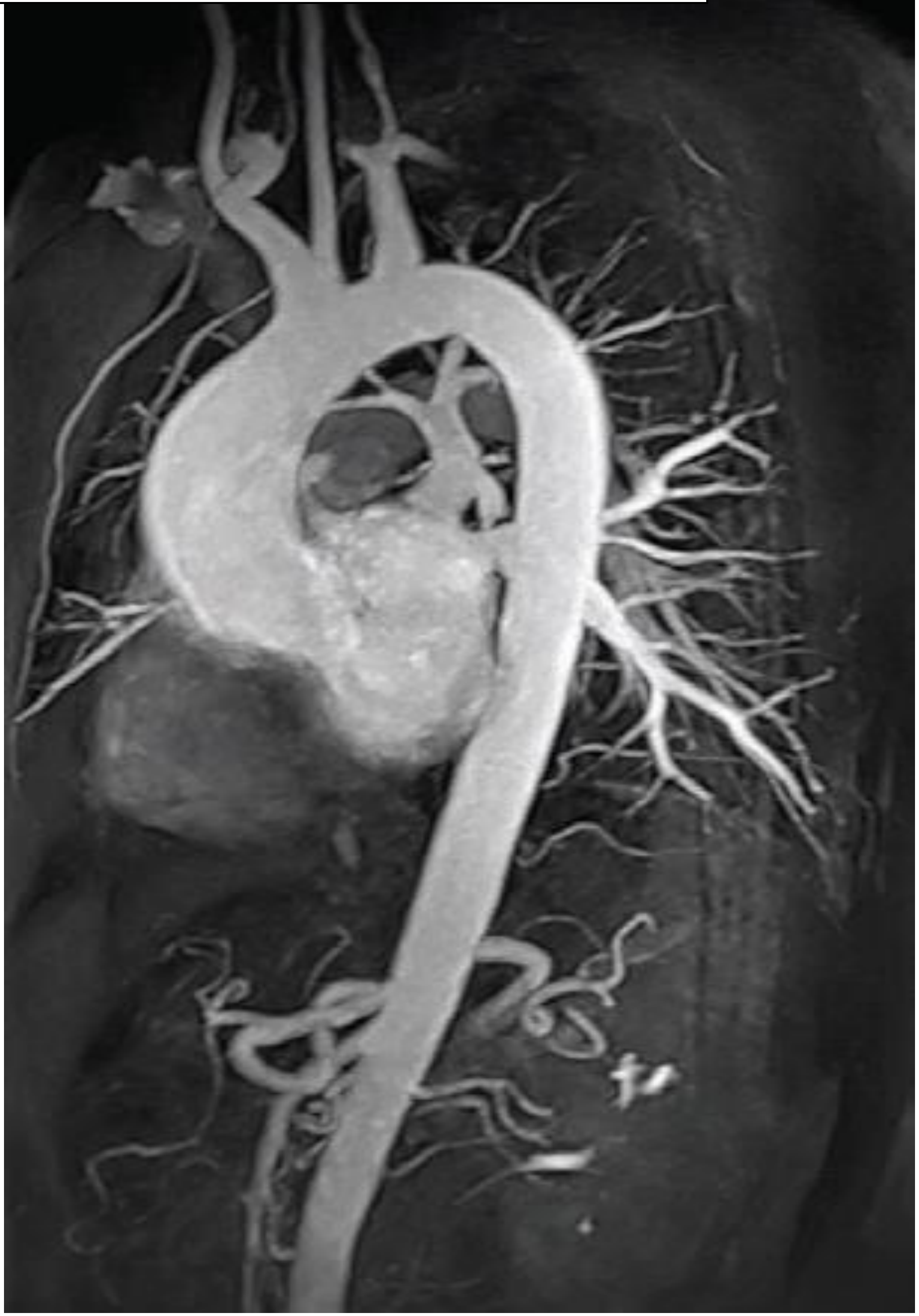
- **What are the differences between Angina pectoris and Myocardial Infarction?**

Clinical note: Coronary Bypass Graft

- The great saphenous vein is commonly used for coronary bypass surgery because
  - It has a diameter equal to or greater than that of the coronary arteries.
  - Can be easily dissected from the lower limb
  - Offers relatively lengthy portions with a minimum occurrence of valves or branching.

Image from: Torsten B. Moeller; Emil Reif. Pocket Atlas of Sectional Anatomy. 3rd edition. Germany by Appl Aprinta Druck, Wemding; 2005

Coronary Angiography



Clinical note: Coronary Angioplasty

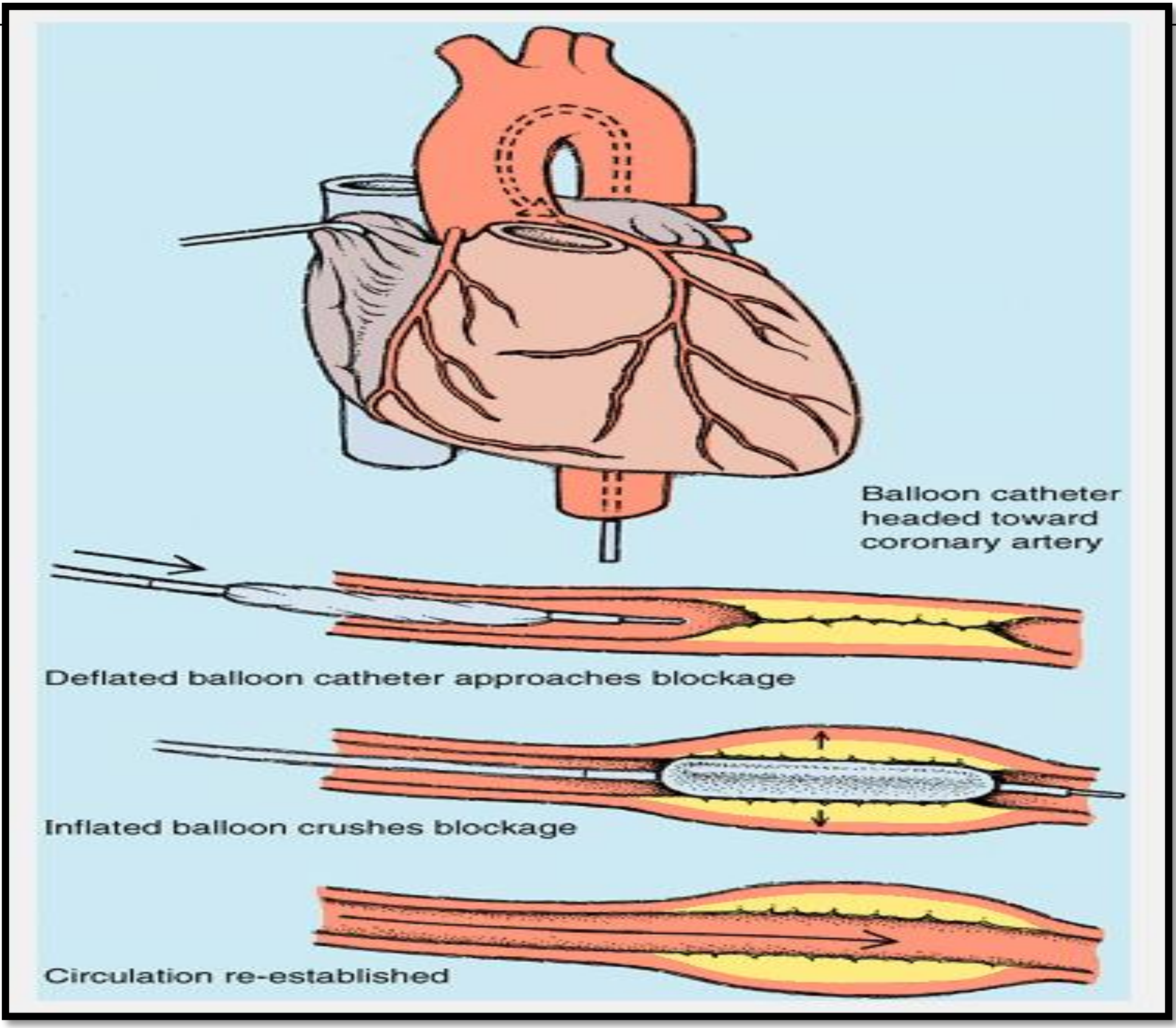

Balloon catheter headed toward coronary artery
Deflated balloon catheter approaches blockage
Inflated balloon crushes blockage
Circulation re-established

Image from: Moore, Keith L.; Dalley, Arthur F, Clinically Oriented Anatomy, 5th Ed. Lippincott Williams & Wilkins; 2006.

Lecture's map

- **Blood supply:**
  - Right and left coronary arteries.
- **Venous drainage:**
  - Coronary sinus.
- Conducting system of the heart.

Venous Drainage of the heart

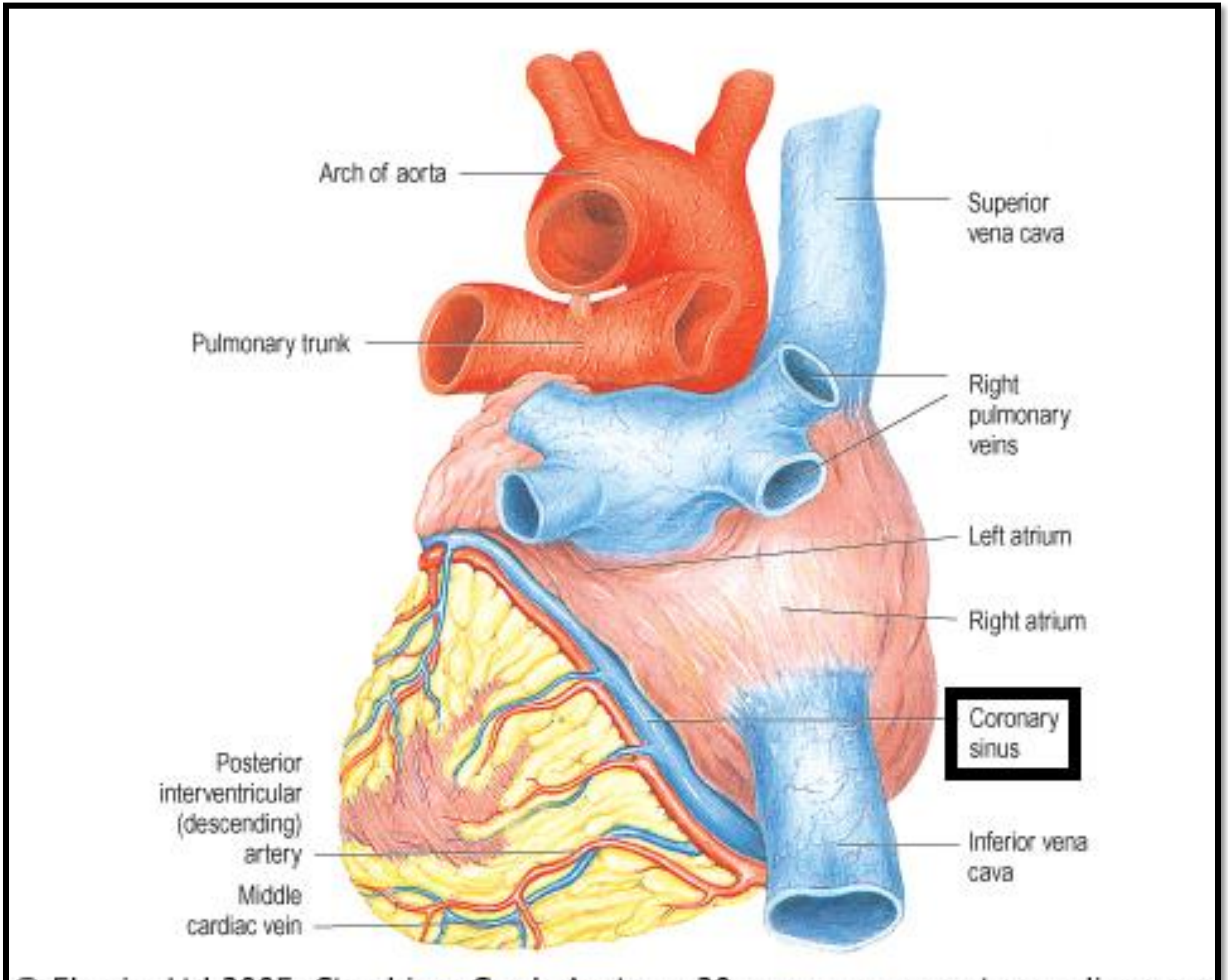
Coronary sinus

Venous Drainage

- The heart is drained **mainly** by veins that empty into the coronary sinus and **partly** by small veins that empty into the right atrium .

The coronary sinus

- It is the main vein of the heart.
- Location: it runs from left to right in the posterior part of the coronary groove.
- Tributaries:
  - At its left end: The great cardiac vein.
  - At its right end: The middle cardiac vein and small cardiac veins
  - Other small veins.



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Tributaries of the coronary sinus (1)

- **The great cardiac vein:**
  - Ascends with the anterior IV branch of the LCA.
  - Then runs around the left side of the heart with the circumflex branch of the LCA to reach the coronary sinus.
  - It drains the areas of the heart supplied by the LCA.
- **The middle cardiac vein:**
  - Accompanies the posterior interventricular branch.
- **The small cardiac vein:**
  - Accompanies the right marginal branch of the RCA.

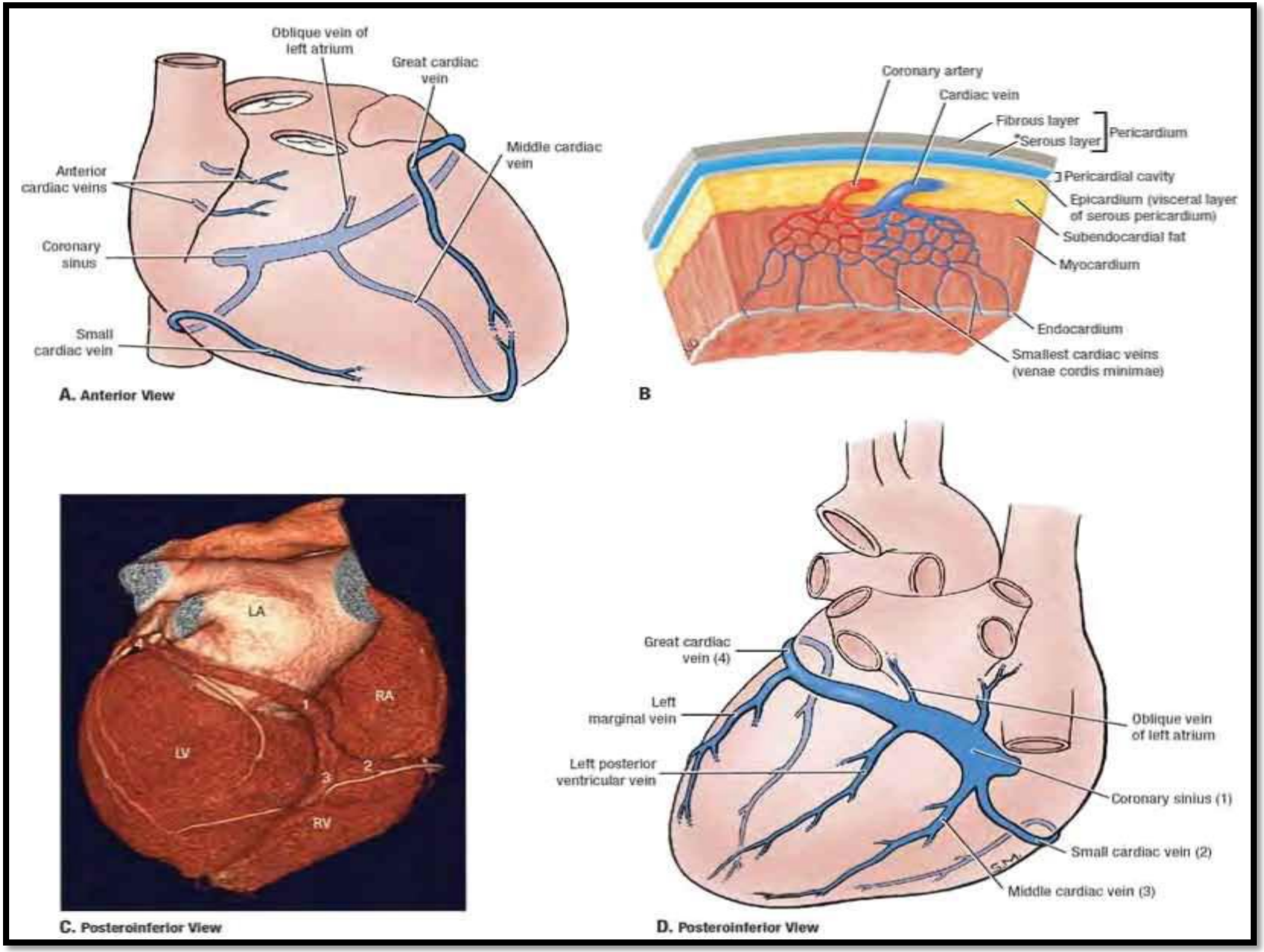
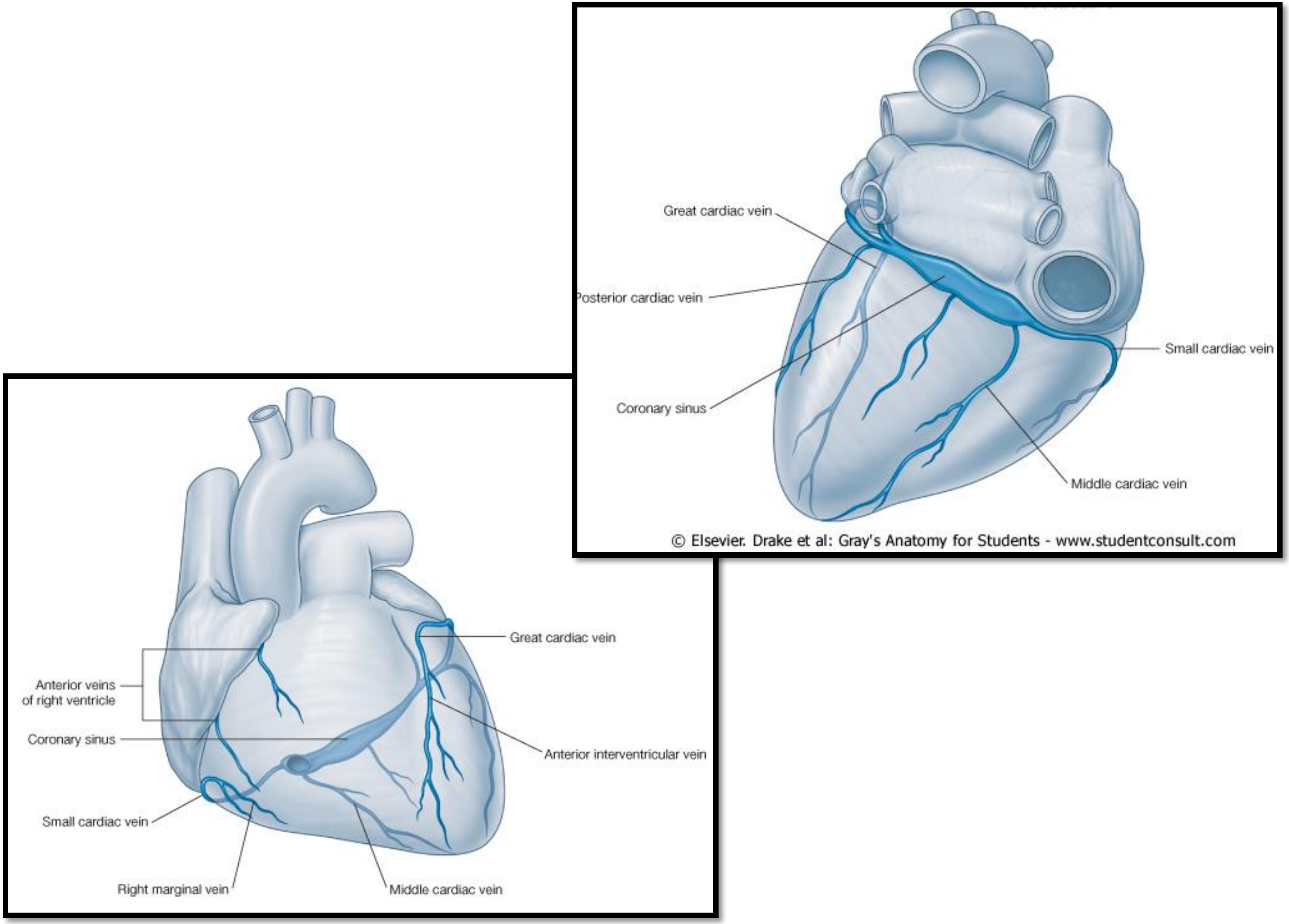


Image from: Moore, Keith L.; Dalley, Arthur F, Clinically Oriented Anatomy, 5th Ed. Lippincott Williams & Wilkins; 2006.

Think about this

- An unusual situation is occurring in the heart: Blood is flowing in the same direction within a paired artery and vein.
- Name the artery and the vein.



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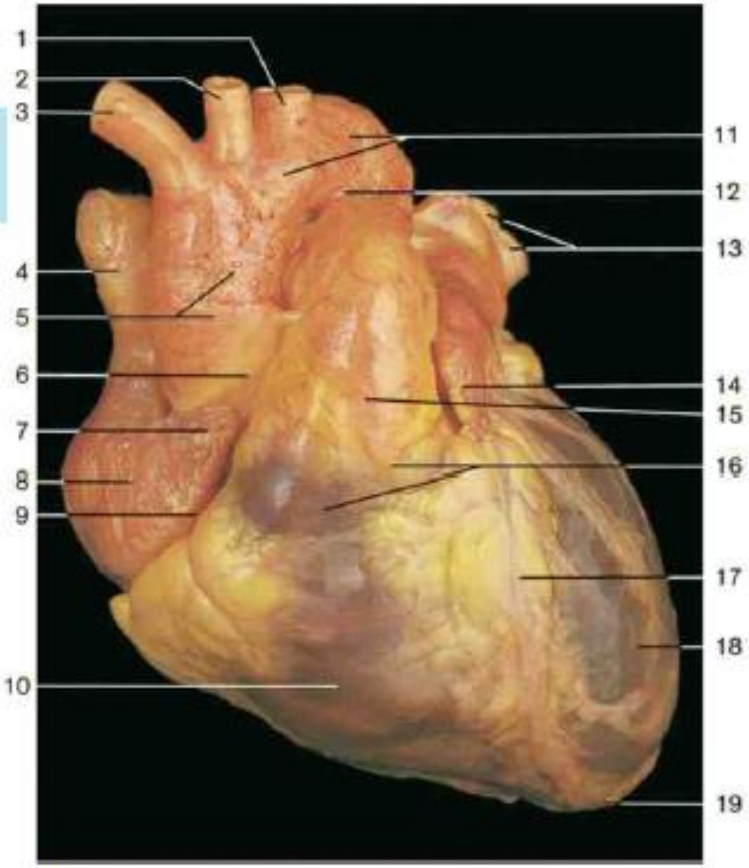
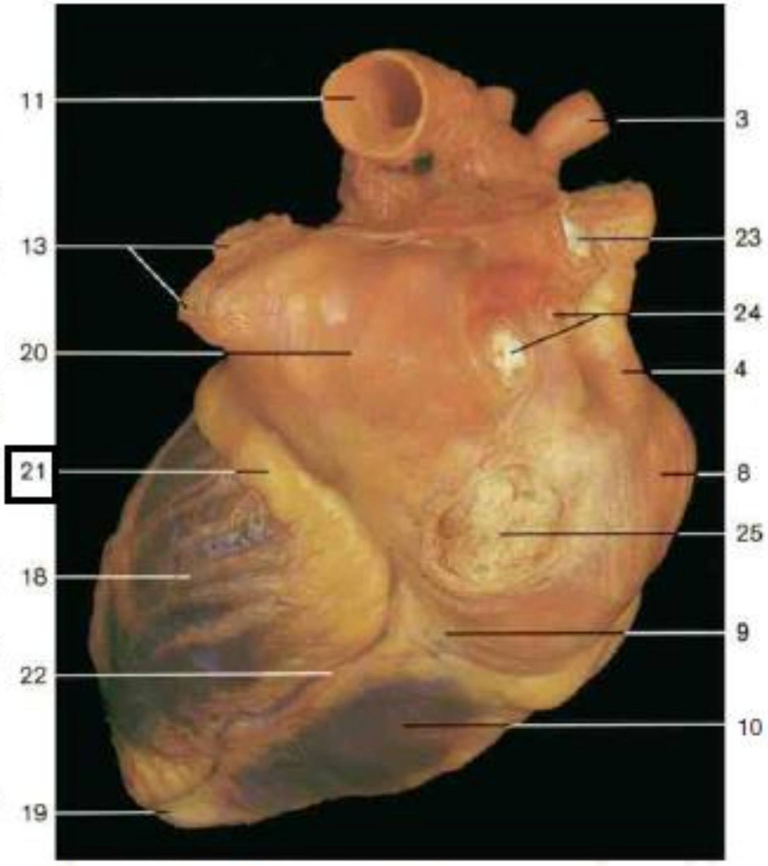
Tributaries of the coronary sinus (2)

- The **oblique vein**
  - It is the remnant of the embryonic left SVC.
- **Other veins:**
  - Several small **anterior cardiac veins** begin over the anterior surface of the right ventricle and usually end **directly** in the right atrium.
  - The smallest cardiac veins (**L. venae cordis minimae**) are minute vessels that begin in the capillaries of the myocardium and open **directly** into the chambers of the heart.



Heart of 30-year-old woman (anterior aspect).

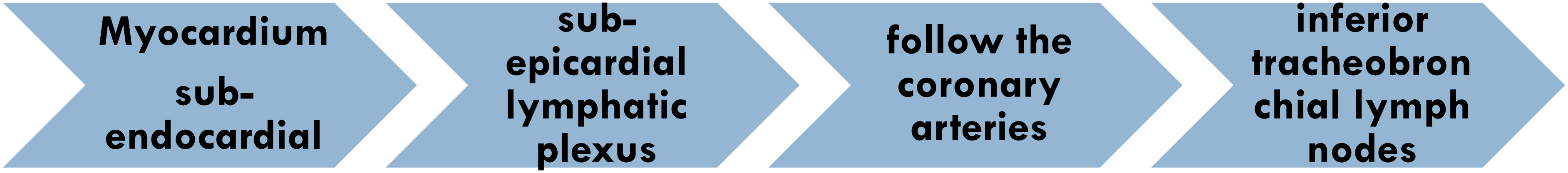


Heart of 30-year-old woman (oblique-posterior view).

1 Left subclavian artery
2 Left common carotid artery
3 Brachiocephalic trunk
4 Superior vena cava
5 Ascending aorta
6 Bulb of the aorta
7 Right auricle
8 Right atrium
9 Coronary sulcus
10 Right ventricle
11 Aortic arch
12 Ligamentum arteriosum
13 Left pulmonary veins
14 Left auricle
15 Pulmonary trunk
16 Sinus of pulmonary trunk
17 Anterior interventricular sulcus
18 Left ventricle
19 Apex of the heart
20 Left atrium
21 Epicardial fat overlying coronary sinus
22 Posterior interventricular sulcus
23 Right pulmonary artery
24 Right pulmonary veins
25 Inferior vena cava

Image from: Johannes W.Rohen; Chihiro Yokochi; Elke Lütjen-Drecoll. Color atlas of anatomy. 7th edition. Lippincott Williams & Wilkins 2011

Lymphatic Drainage



Myocardium

sub-endocardial

sub-epicardial lymphatic plexus

follow the coronary arteries

inferior tracheobronchial lymph nodes

Lecture's map

- **Blood supply:**
  - Right and left coronary arteries.
- **Venous drainage:**
  - Coronary sinus.
- **Conducting system of the heart.**

Conducting System of the Heart

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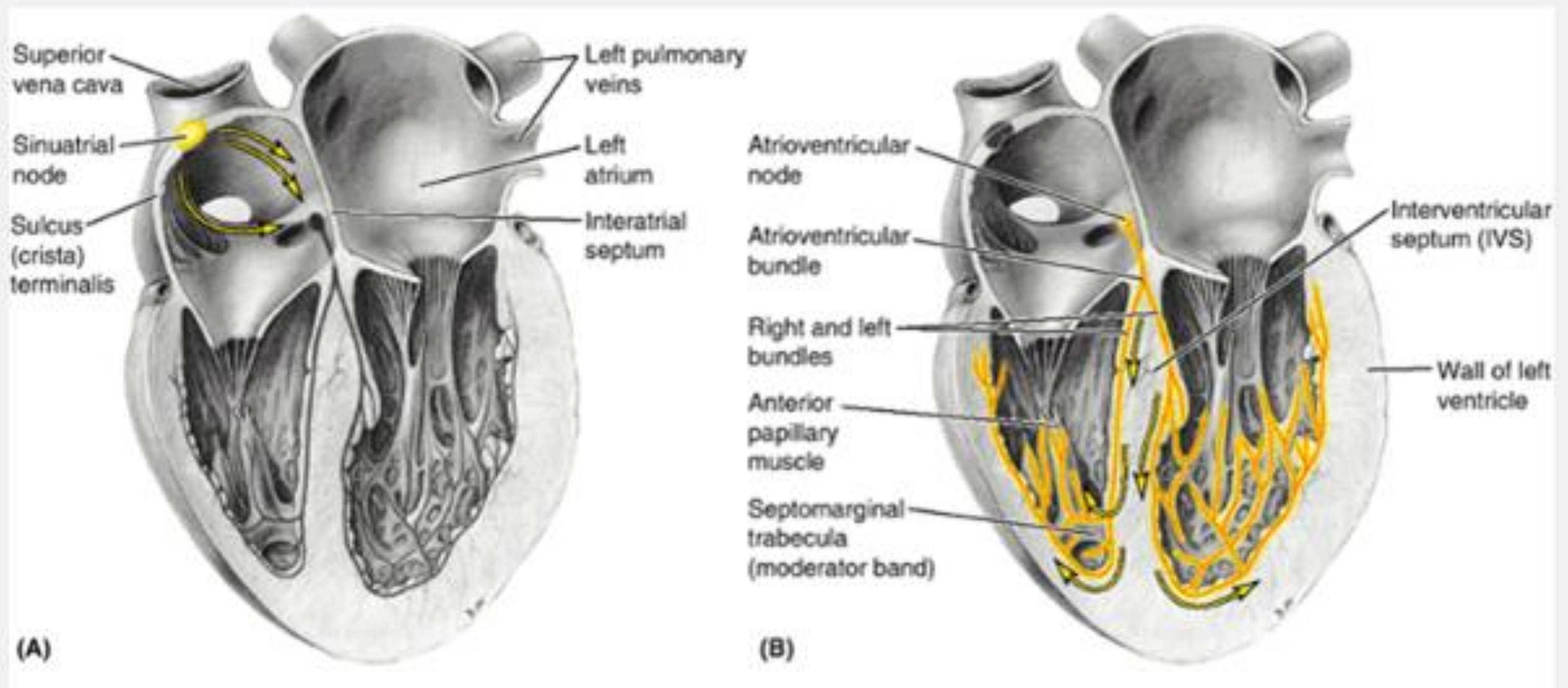
Conducting System of the Heart

- It consists of cardiac muscle cells and highly specialized conducting fibers for initiating impulses and conducting them rapidly through the heart.
- **Function:** it coordinates the cardiac cycle.



Anterosuperior views

Image from: Moore, Keith L.; Dalley, Arthur F, Clinically Oriented Anatomy, 5th Ed. Lippincott Williams & Wilkins; 2006.

Sinuatrial (SA) node

- **Location: at the junction of the SVC and right atrium, near the superior end of the sulcus terminalis.**
- **Function: it initiates and regulates the impulses for contraction.**
  - **The contraction signal from the SA node spreads myogenically (through the musculature) of both atria.**
- **Blood supply: SA nodal artery:**
  - **From RCA in 60% of people.**
  - **From the LCA in 40%.**
- **Innervation:**
  - **Sympathetic system: accelerates the heart rate.**
  - **Parasympathetic system: inhibits the heart rate toward its basal rate.**

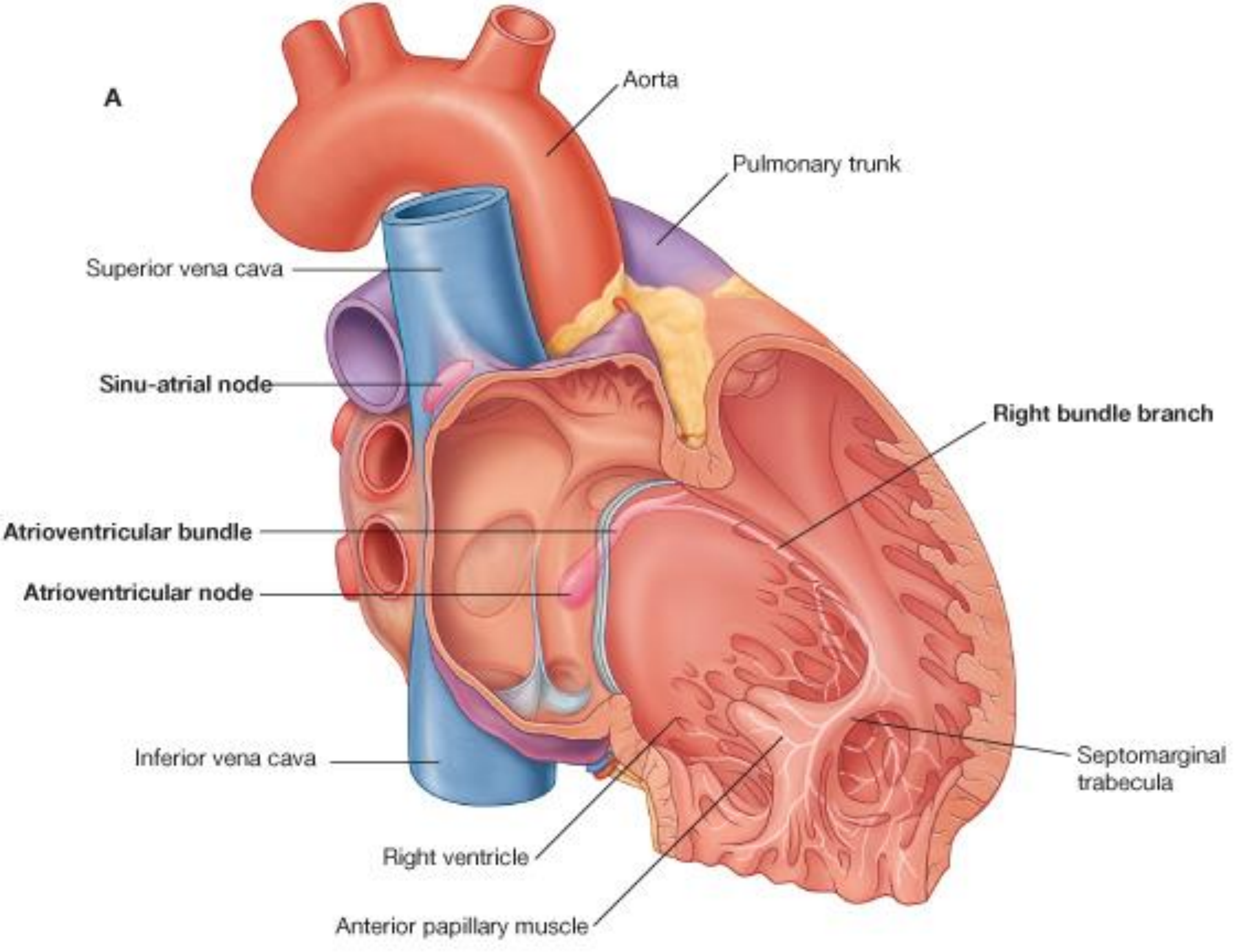
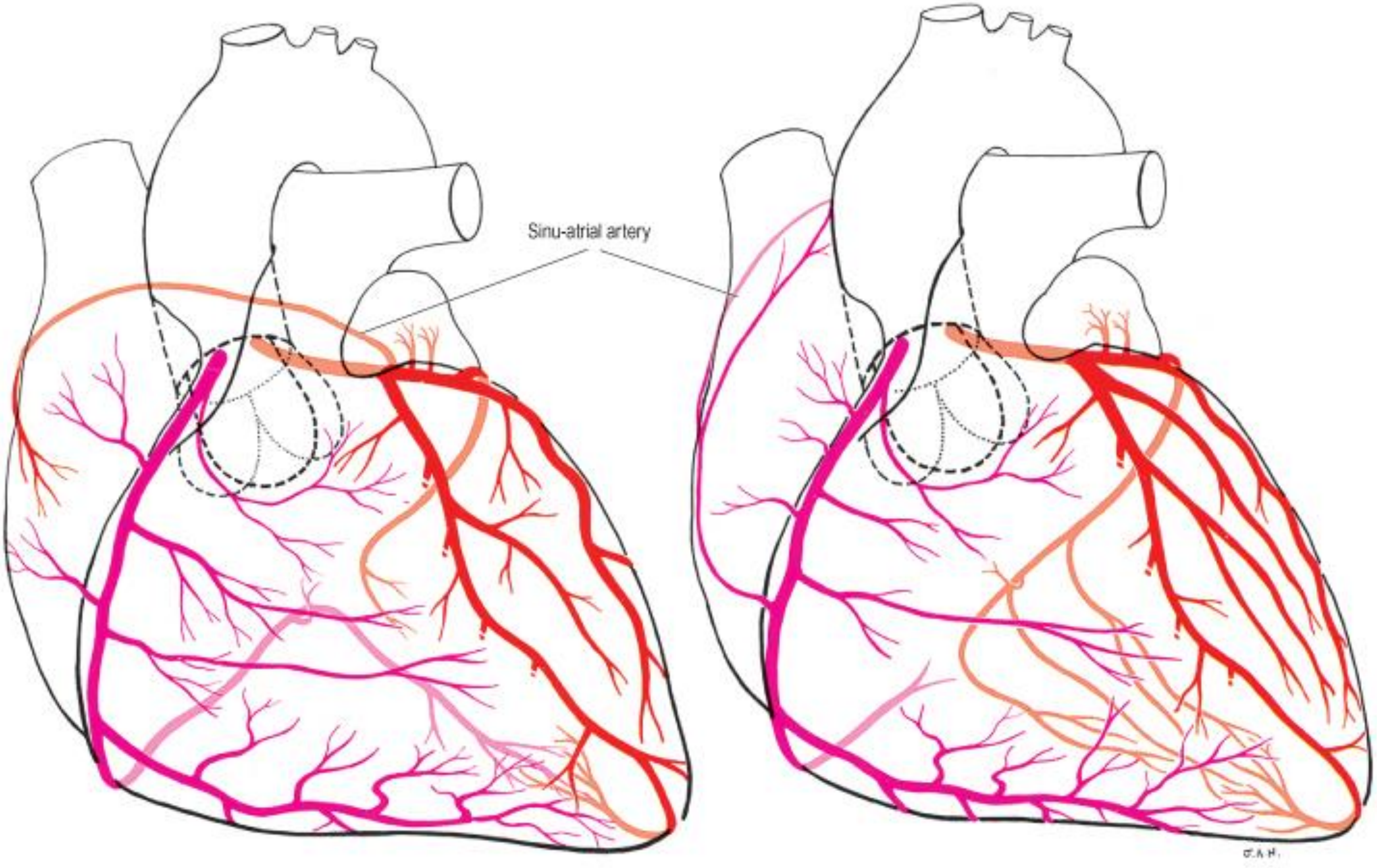


Image from: Richard L.Drake, Wayne Vogl,Adam W.M.Mitchell, GRAYS anatomy for students, Elsevier Inc. 2007



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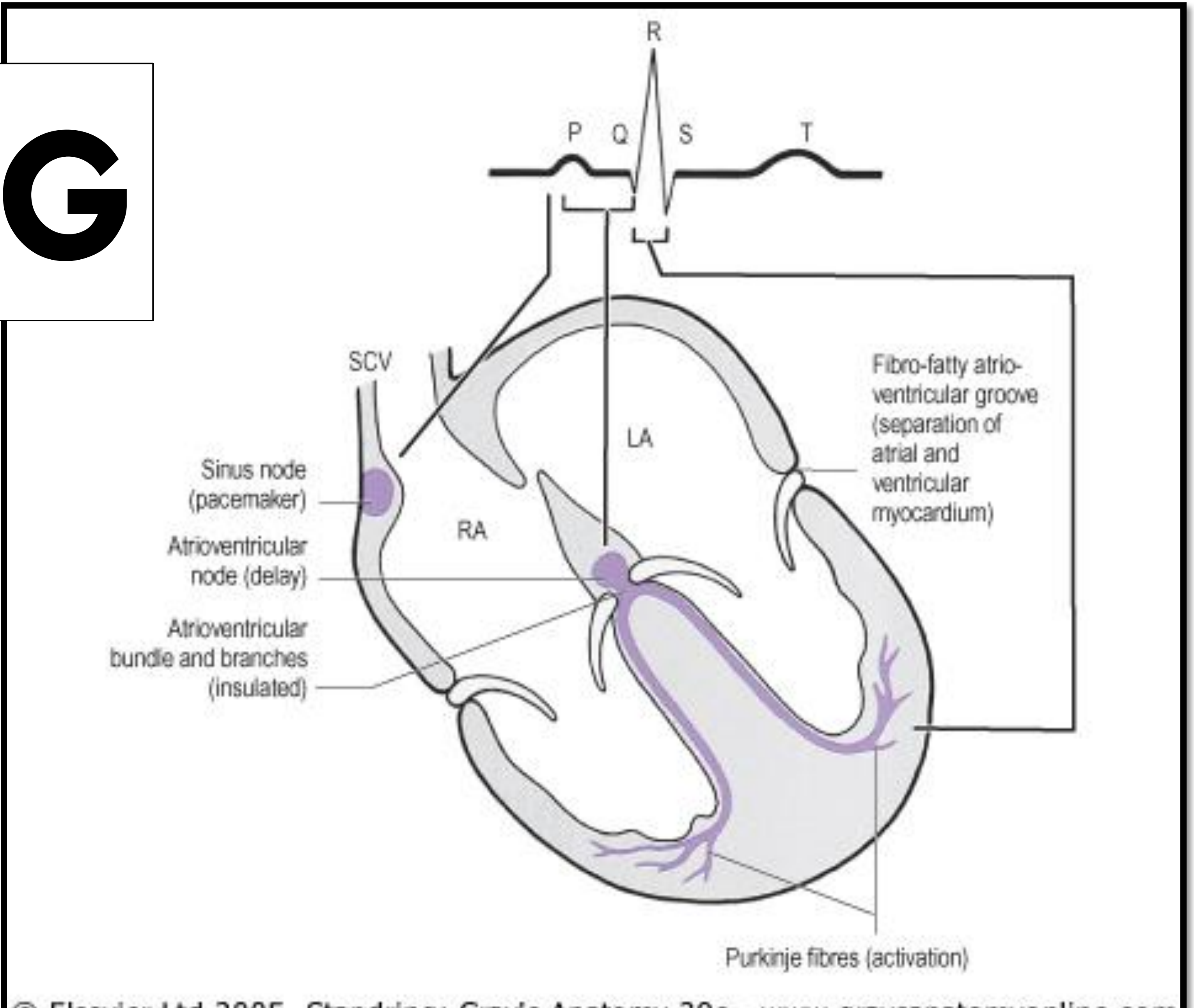
Atrioventricular (AV) node

- **Location**: in the interatrial septum near the opening of the coronary sinus (right atrium).
- **Function**: it distributes the signal to the ventricles through the AV bundle .
- **Blood supply**: by the AV nodal artery from the posterior IV artery, a branch of the RCA in 80% of people.
- **Innervation**:
  - Sympathetic stimulation speeds up conduction.
  - Parasympathetic stimulation slows it down.

Atrioventricular (AV) bundle

- It is the only bridge between the atrial and ventricular myocardium, passes from the AV node along the IV Septum.
- The AV bundle divides into right and left bundles. These branches then ramify into subendocardial branches (Purkinje fibers), which extend into the walls of the respective ventricles.

ECG


R
P
Q
S
T
SCV
LA
RA
Sinus node (pacemaker)
Atrioventricular node (delay)
Atrioventricular bundle and branches (insulated)
Fibro-fatty atrio-ventricular groove (separation of atrial and ventricular myocardium)
Purkinje fibres (activation)

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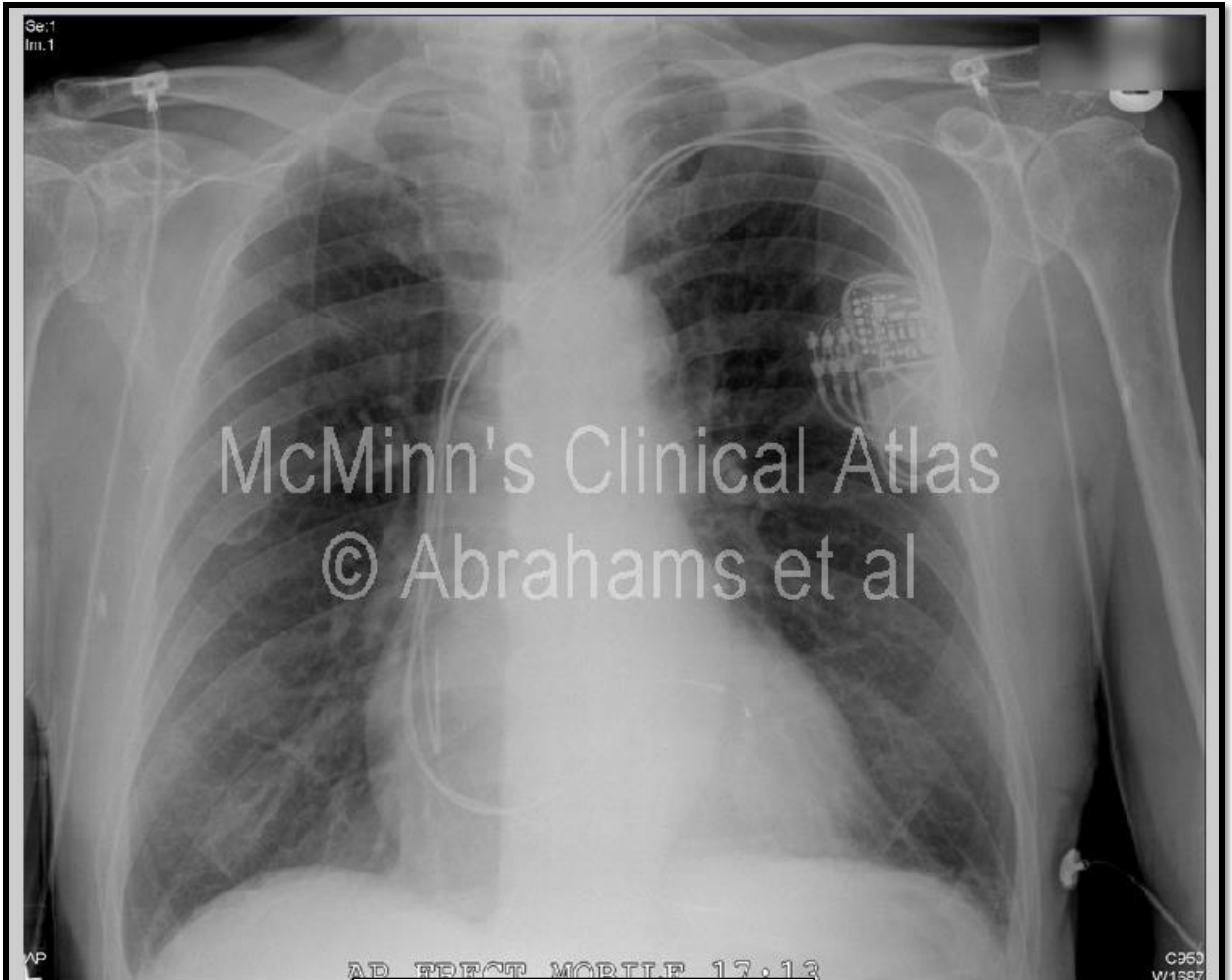

McMinn's Clinical Atlas
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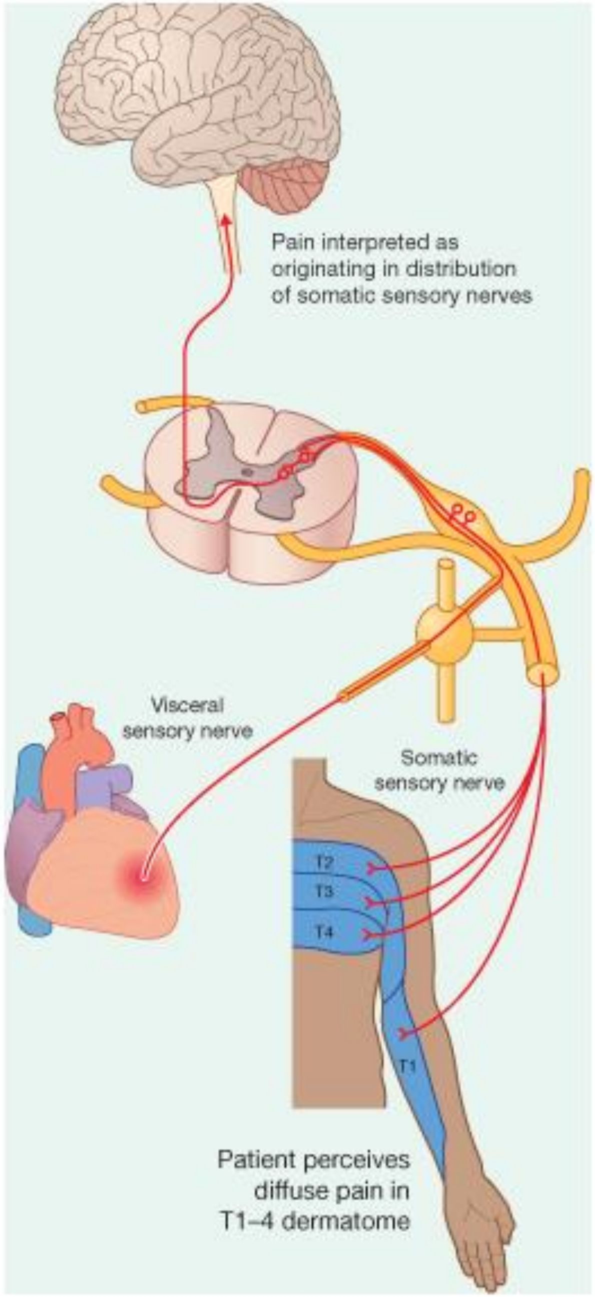
Image from: Abraham's et al , McMinn clinical atlas.

Clinical note: Referred pain (1)

- ***When cardiac cells die during a myocardial infarction, pain fibers (visceral) are stimulated.***
- ***These sensory fibers (visceral) follow the course of sympathetic fibers that innervate the heart and enter the spinal cord between TI and TIV levels.***
- ***At this level, afferent nerves (somatic) from spinal nerves T1 to T4 also enter the spinal cord via the posterior roots.***


Pain interpreted as originating in distribution of somatic sensory nerves
Visceral sensory nerve
Somatic sensory nerve
T2
T3
T4
T1
Patient perceives diffuse pain in T1–4 dermatome

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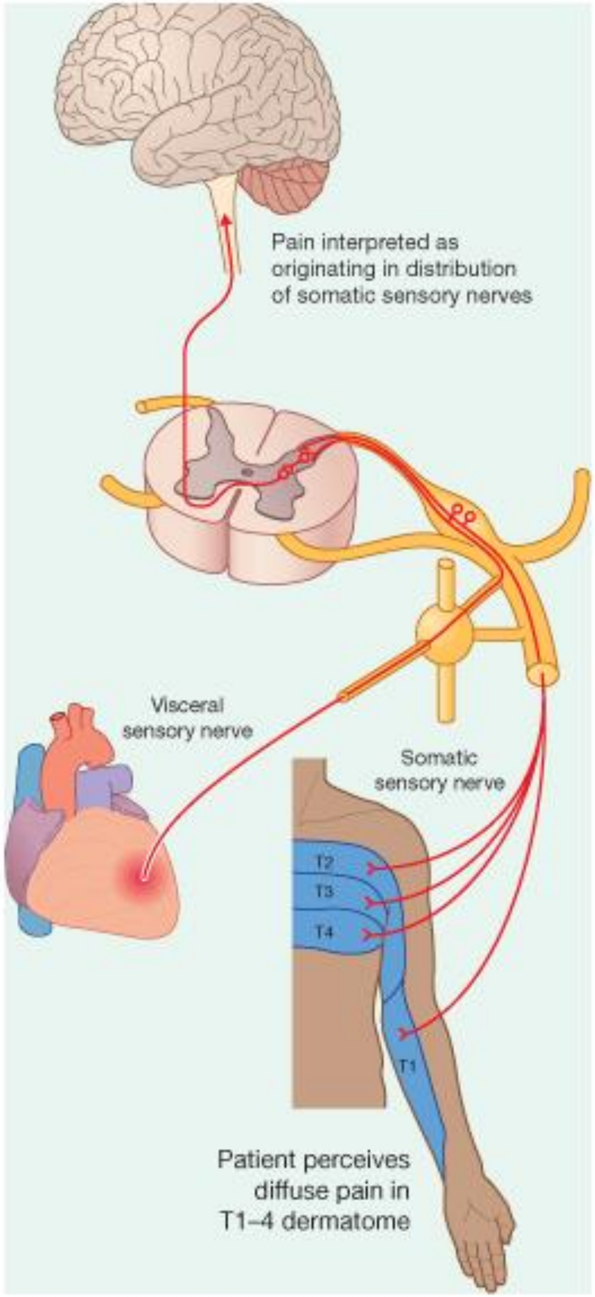
Clinical note: Referred pain (2)

- ☐ *Both types of afferents (visceral and somatic) ascend to the somatosensory areas of the brain that represent the T1 to T4 levels.*
- ☐ *The brain is unable to distinguish clearly between the visceral sensory distribution and the somatic sensory distribution and therefore the pain is interpreted as arising from the somatic regions rather than the visceral organ*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Summary

Lecture's map

- **Blood supply:**
  - Right and left coronary arteries.
- **Venous drainage:**
  - Coronary sinus.
- Conducting system of the heart.

Please try to answer this question

- The right coronary artery:
  - Arises from the posterior aortic sinus.
  - Supplies the SA node.
  - Descends in the left atrioventricular groove.
  - Gives rise to an anterior interventricular branch.
  - Passes forward between the right auricle and the aorta.

Please try to answer this question

- Which one of the following veins drain directly to the right atrium:
  - Small cardiac.
  - Middle cardiac.
  - Anterior cardiac.
  - Posterior vein of the left ventricle.
  - Great cardiac.

Please try to answer this question

- **Which one of the following statements regarding the conducting system of the heart is true :**
  - The impulse for cardiac contraction spontaneously begins in the SA node
  - The AV bundle is the sole pathway for conduction of the waves of contraction between the atria.
  - The SA node is commonly supplied by the left coronary artery
  - The sympathetic nerves to the heart slow the rate of discharge from the SA node.
  - The atrioventricular bundle descends behind the marginal cusp of the tricuspid valve.

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